ECEN 250 Lab8 - Passive Filters

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Purposes:

- Learn how to perform AC frequency sweeps in SPICE.
- Simulate low-pass, high-pass, bandpass, and bandreject filters.
- Use lab equipment to evaluate performance of low-pass, high-pass, bandpass, and bandreject filters.

Procedure:

Part 1a - SPICE simulation of an RL filter

Simulate the following circuit in LTspice (refer to the Lab8 Appendix):

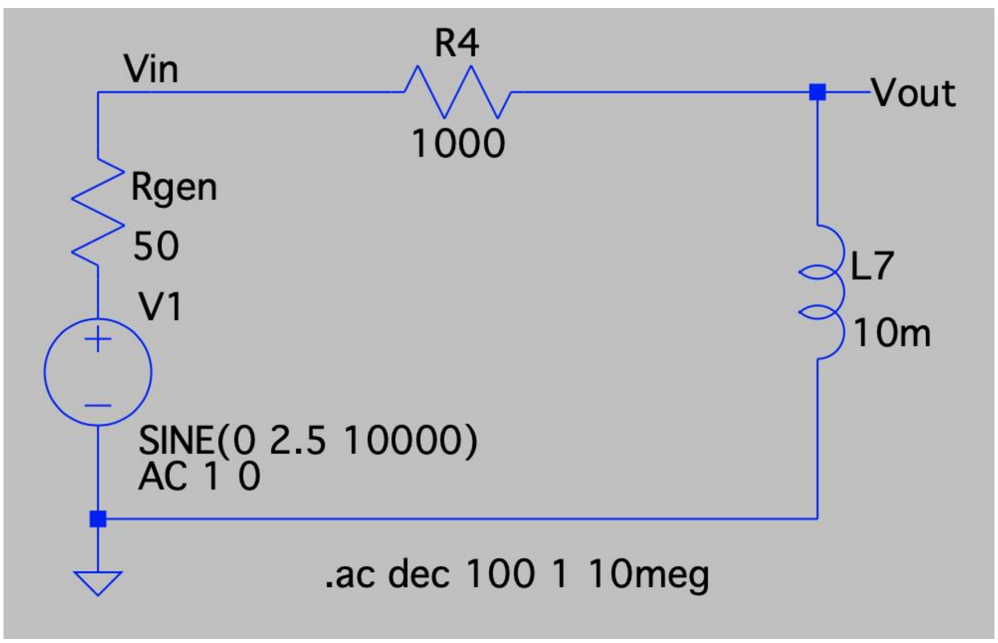


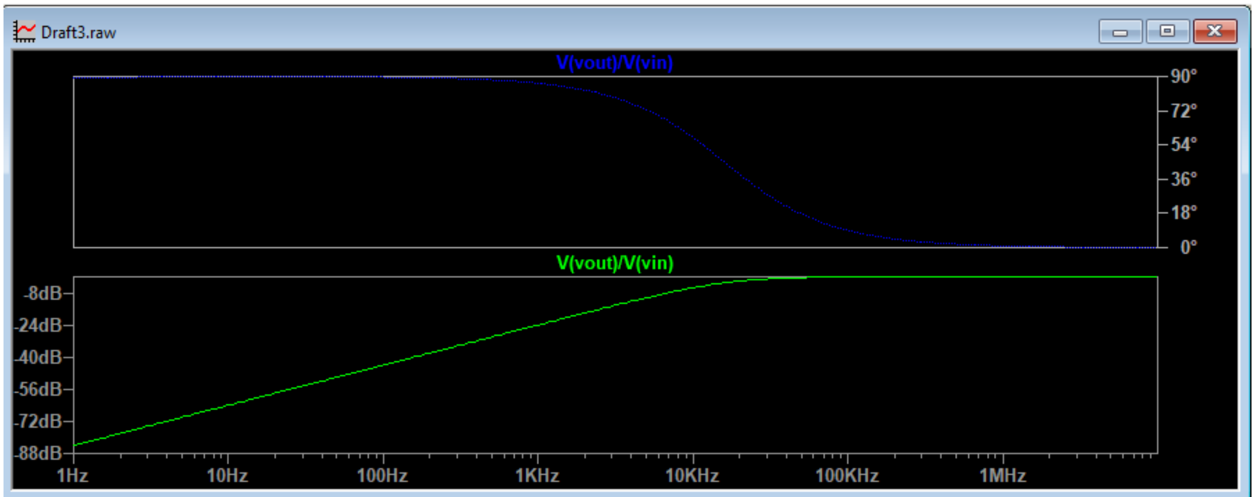
Figure 1a - Simulating a series RL filter with an AC Source

Note: The "SINE(0 2.5 10000)" only has meaning in a transient (.tran) simulation. It is the "AC 1 0" that matters in an AC simulation.

Simulate and plot the "V(vout)/V(vin)" signal pair. It will consist of a log/log frequency sweep with both magnitude and phase.

Since both magnitude and phase show up on the same plot window, it is sometimes helpful to add a second plot pane, so this information doesn't overlap each other. To turn off magnitude, right-click on magnitude axis and select "Don't Plot Magnitude". To turn off phase, do the same thing on the phase axis.

Place a screenshot of your simulation below showing "V(vout)/V(vin)":



Complete the following table from the simulation data:

Frequency	Magnitude Vout/Vin (in dB)	Magnitude Vout/Vin (in V/V)	Phase Vout/Vin (in degrees)
1 Hz	-84 dB	60 uV	90
1 kHz	-24 dB	62 mV	86
15915.5 Hz	-3 dB	720 mV	46
10 MHz	0	1V	0

Notes on Magnitude: As frequency goes up, the magnitude also goes up and the phase shift goes down

The SPICE AC simulation defaults to a log-log scale. The Y-axis is in decibels (dB), and the X-axis is incremented by powers of 10.

To convert magnitude (dB) to magnitude (V/V), $Vout(F)/Vin(F) = 10^{(\text{mag dB})/20}$

Part 1b - SPICE simulation of an RC filter

Simulate the following circuit in LTspice:

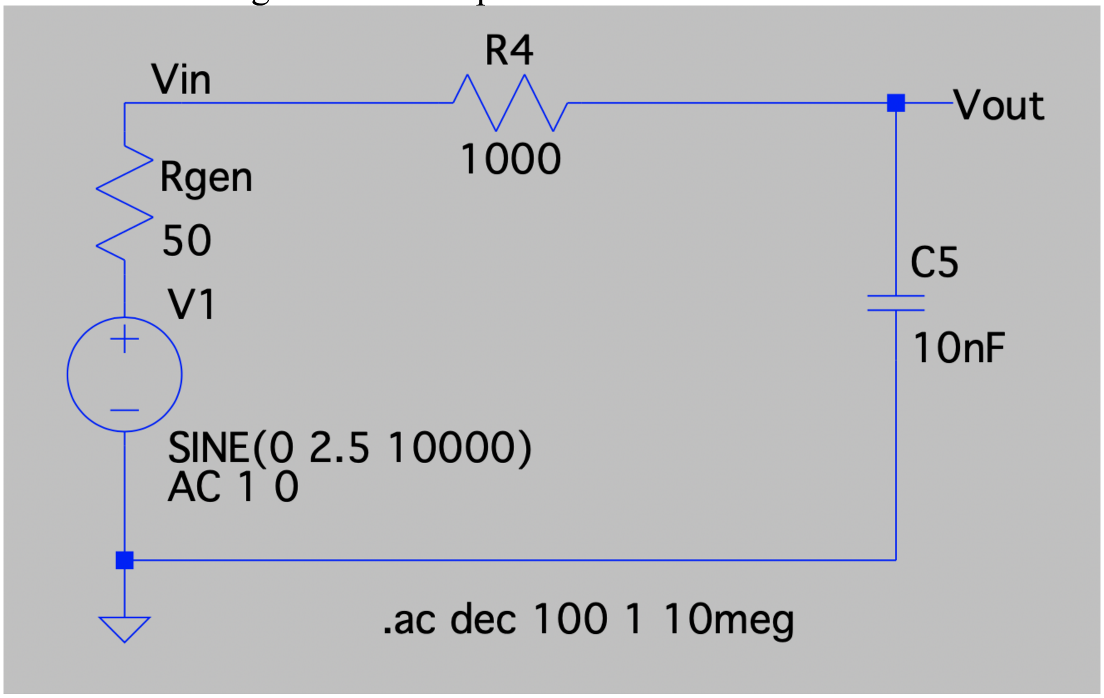
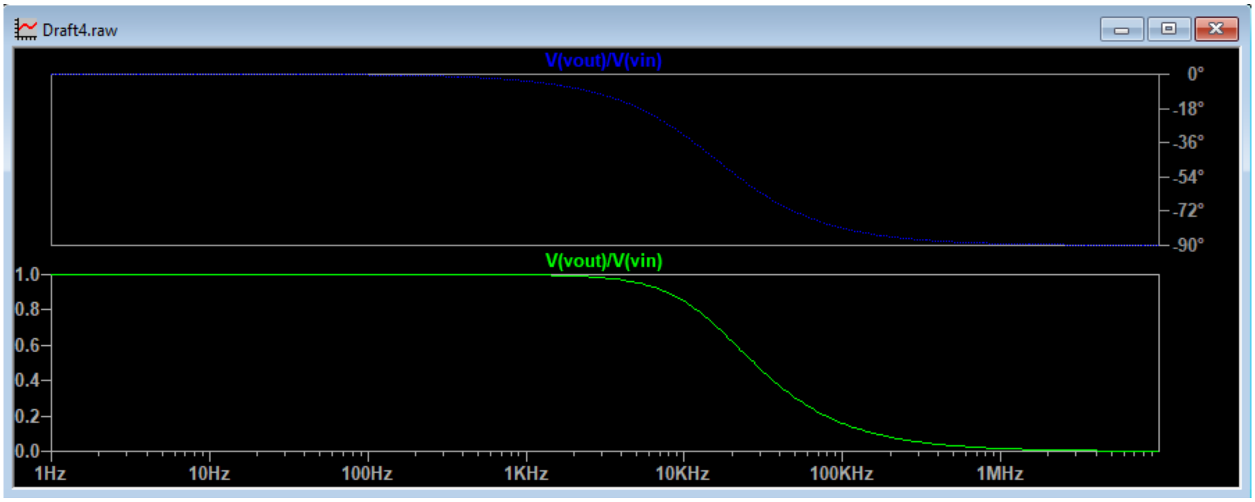


Figure 1b - Simulating a series RC filter with an AC Source

Place a screenshot of your simulation below showing "V(vout)/V(vin)":



Complete the following table from the simulation data:

Frequency	Magnitude Vout/Vin (in dB)	Magnitude Vout/Vin (in V/V)	Phase Vout/Vin (in degrees)
1 Hz	0 dB	1V	0
1 kHz	0 dB	1V	0
15915.5 Hz	-3 dB	1V	0
10 MHz	-56 dB	1.5mV	-90

Part 1c - SPICE simulation of an RLC Bandpass filter

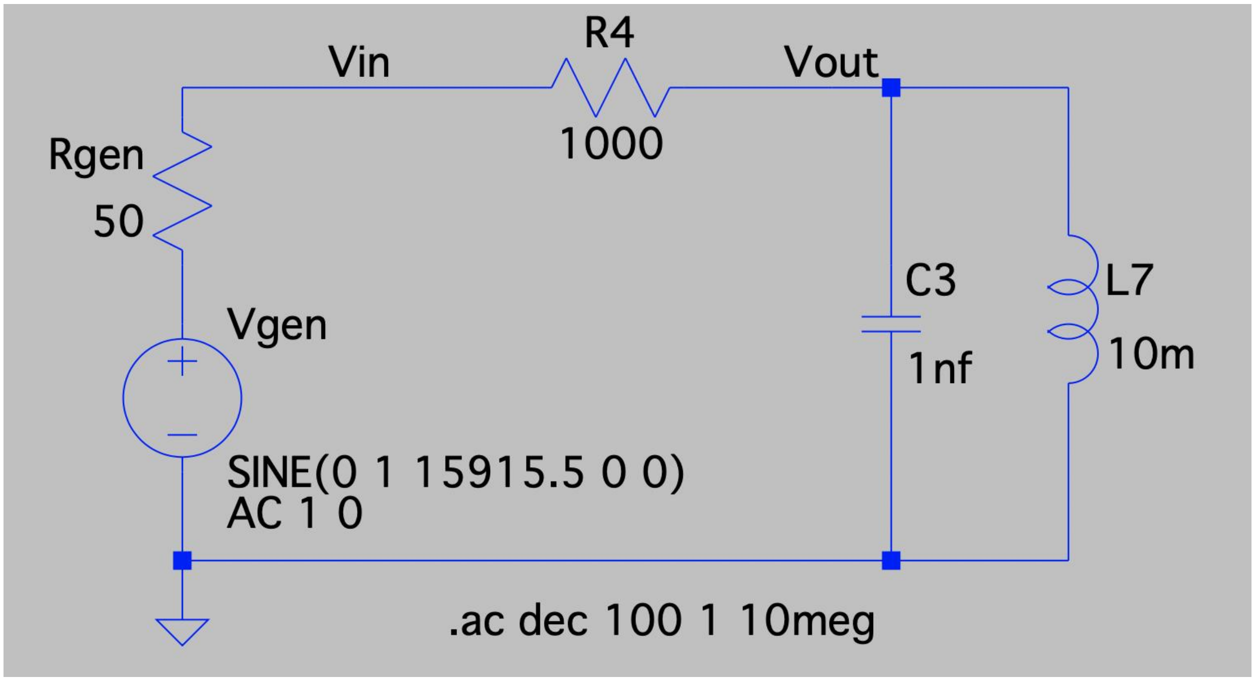
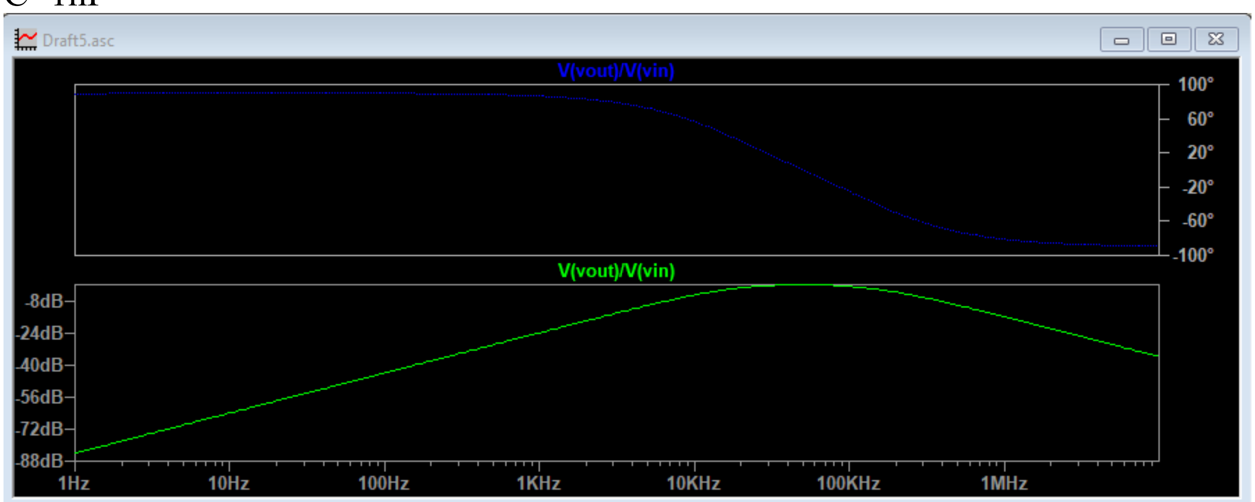


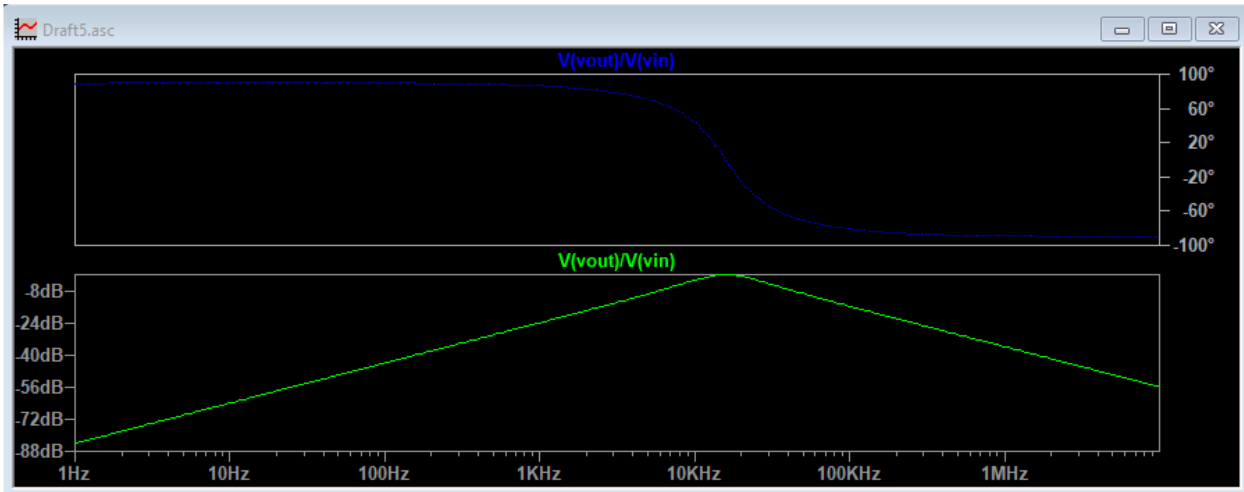
Figure 1c - Simulating a RLC Bandpass Filter with an AC Source

Place a screenshots of your simulations below showing "V(vout)/V(vin)" for C=1nF, 10nF and 100nF:

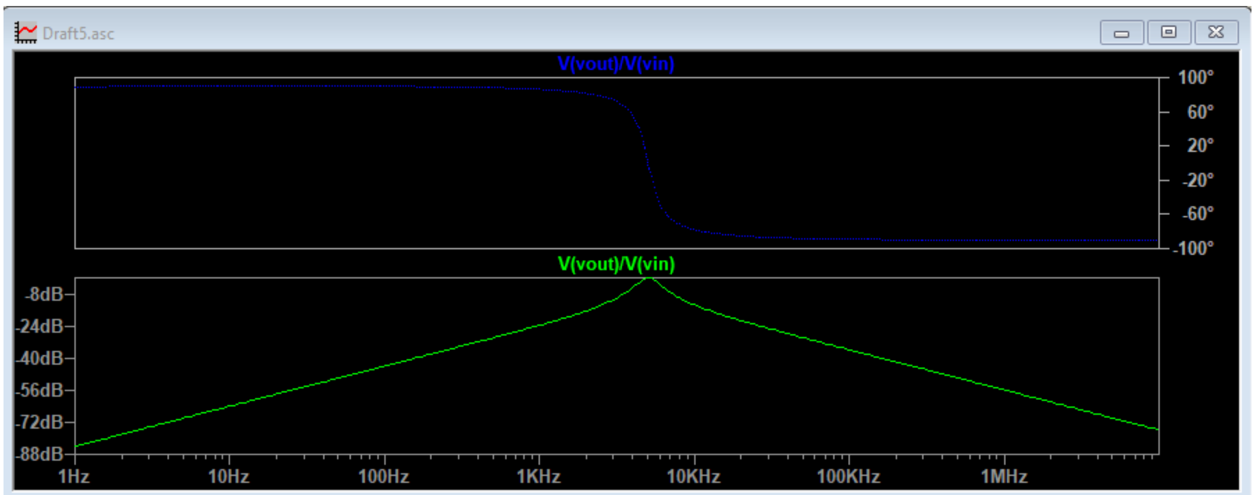
C=1nF



C=10nF



C=100nF



Complete the following table from the simulation data:

C Value	L Value	Center Freq. (Hz)	Center Freq. (rad/s)	Low Cutoff Freq. (Hz)	High Cutoff Freq. (Hz)	Band-width (Hz)	Band-width (rad/s)	Q
1nF	10mH	50326 Hz	316228 rad/s	35580 Hz	71182 Hz	159155 Hz	1000000 rad/s	0.316
10nF	10mH	15916 Hz	100000 rad/s	11253 Hz	22512 Hz	15916 Hz	100000 rad/s	1
100nF	10mH	5033 Hz	31623 rad/s	3558 Hz	7119 Hz	1592 Hz	10000 rad/s	3.16
100nF	1mH	15916 Hz	100000 rad/s	11253 Hz	22512 Hz	1592 Hz	10000 rad/s	10

Part 1d – SPICE simulation of an RLC Bandreject filter

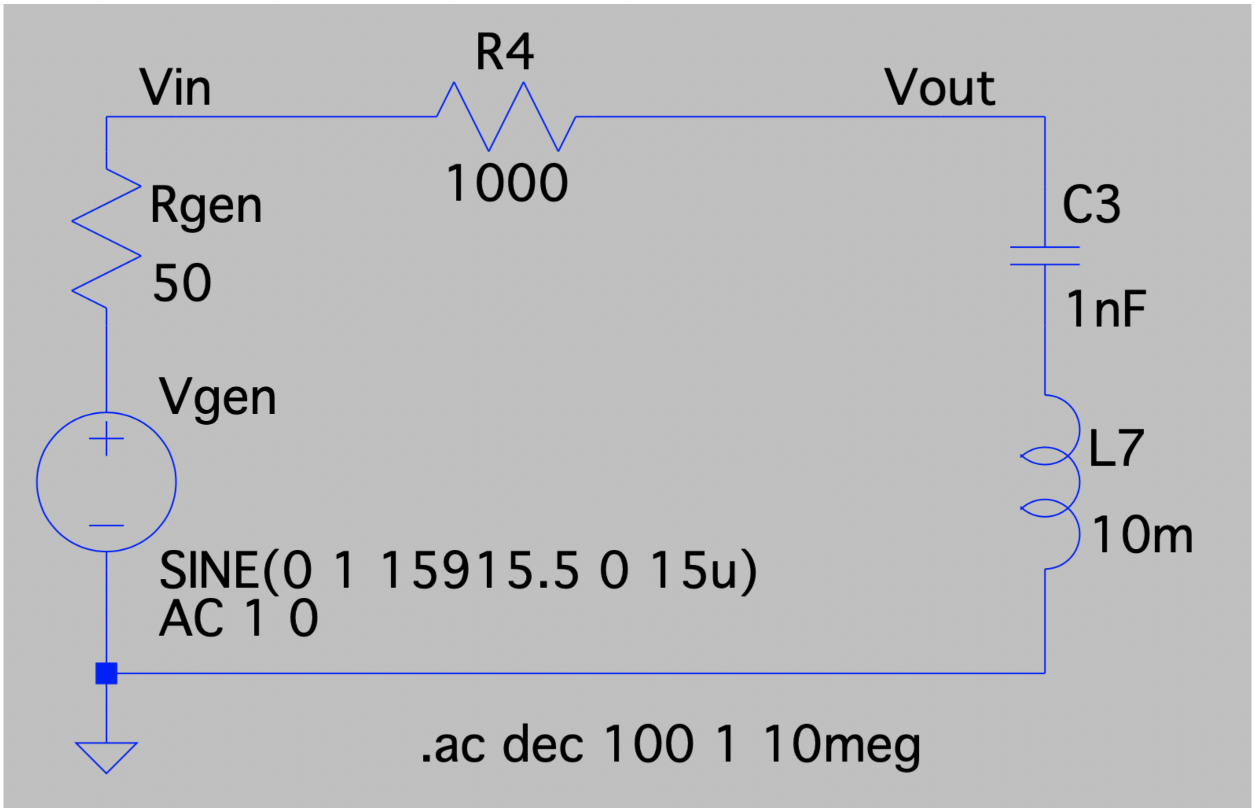
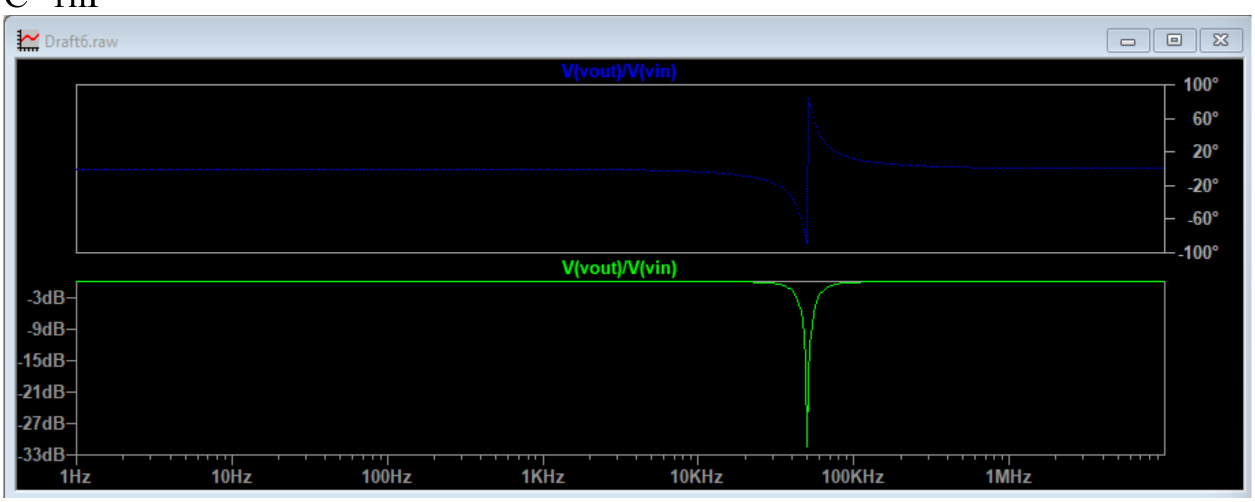


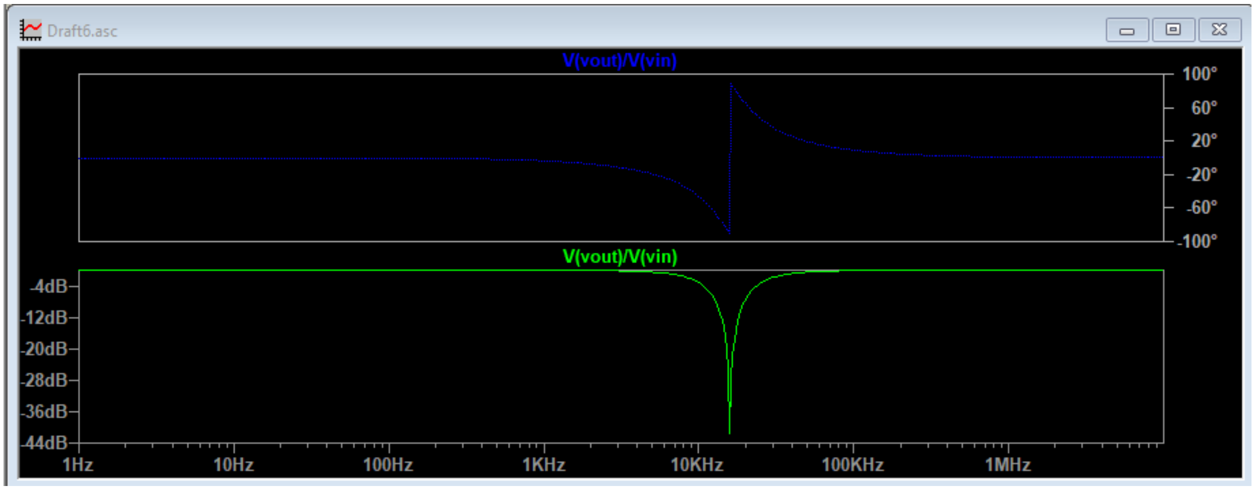
Figure 1d – Simulating a Series RLC Bandreject Filter with an AC Source

Place a screenshots of your simulations below showing “V(vout)/V(vin)” for C=1nF, 10nF and 100nF:

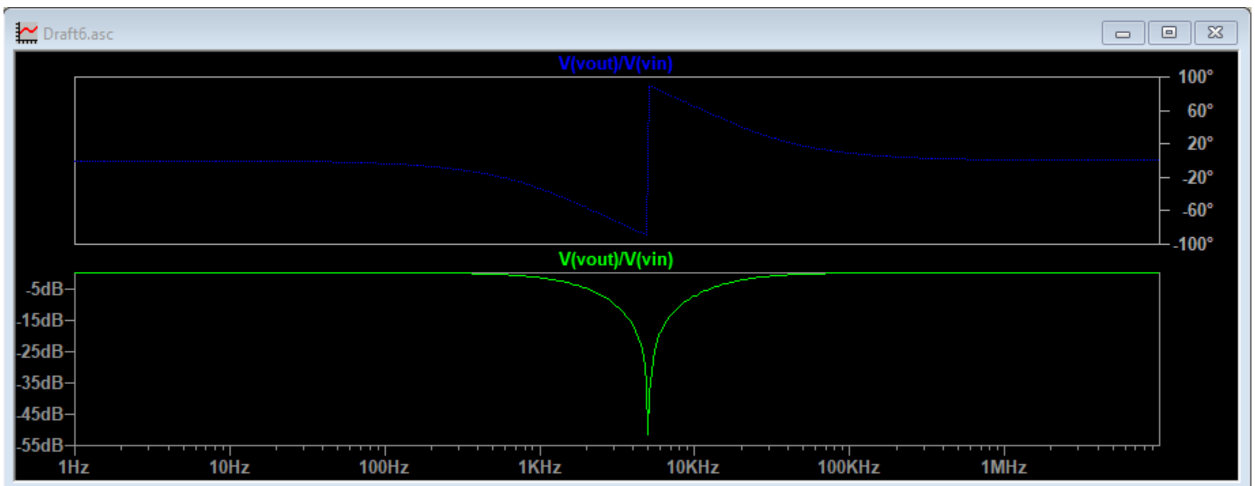
C=1nF



C=10nF



C=100nF



Complete the following table from the simulation data:

C Value	L Value	Center Freq. (Hz)	Center Freq. (rad/s)	Low Cutoff Freq. (Hz)	High Cutoff Freq. (Hz)	Band-width (Hz)	Band-width (rad/s)	Q
1nF	10mH	50326 Hz	316228 rad/s	35580	71182	15915	100000	3.16
10nF	10mH	15916 Hz	100000 rad/s	11253	22512	15915	100000	1
100nF	10mH	5033 Hz	31623 rad/s	3558	7119	15915	100000	0.316
100nF	1mH	15916 Hz	100000 rad/s	11253	22512	159155	1000000	0.1

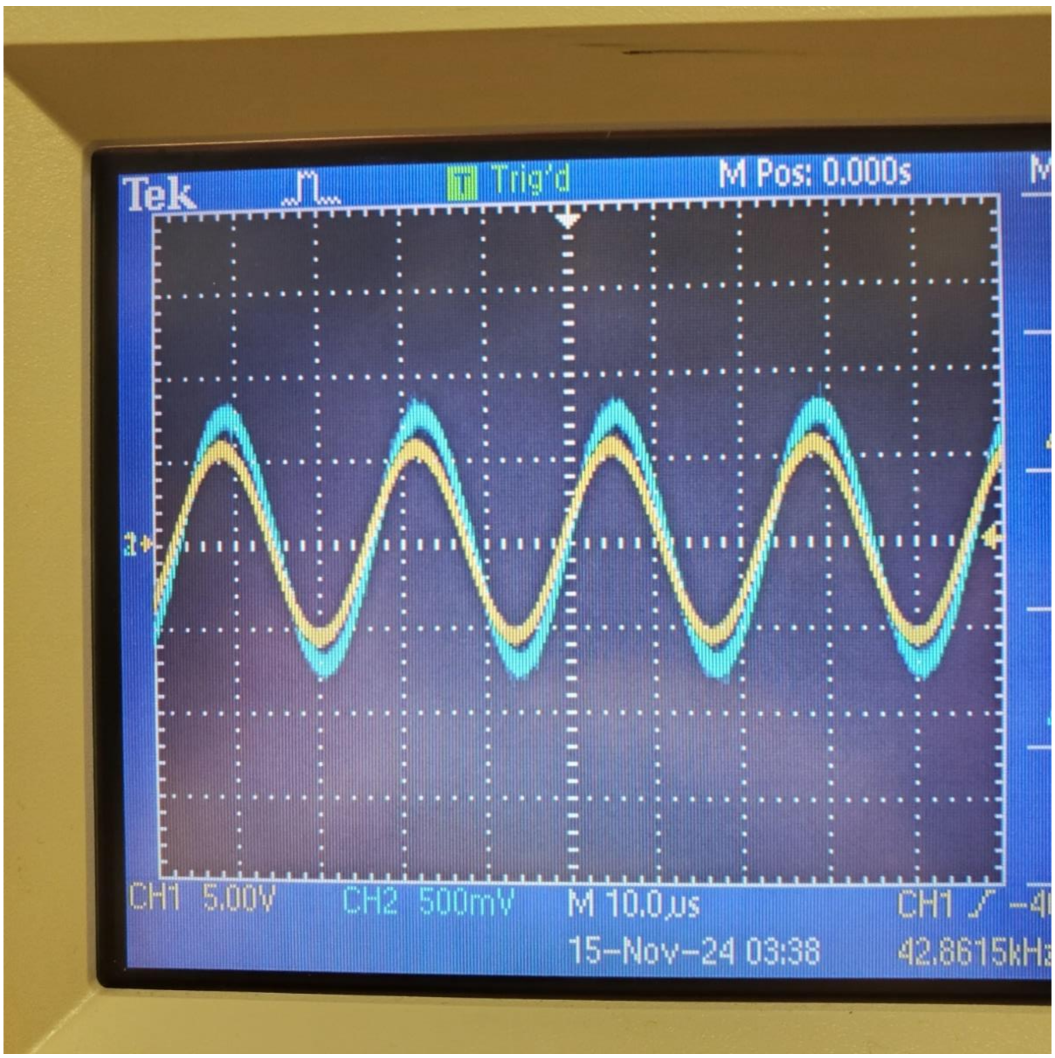
Part 2a - Construct the physical circuit of part 1c for L=1mH, C=100nF

With an oscilloscope and function generator, find the center frequency (in Hz): 15916 Hz

Find the low cutoff frequency (in Hz): 11253 Hz

Find the high cutoff frequency (in Hz): 22512 Hz

Place an oscilloscope picture of the input and output signals at the center frequency below:



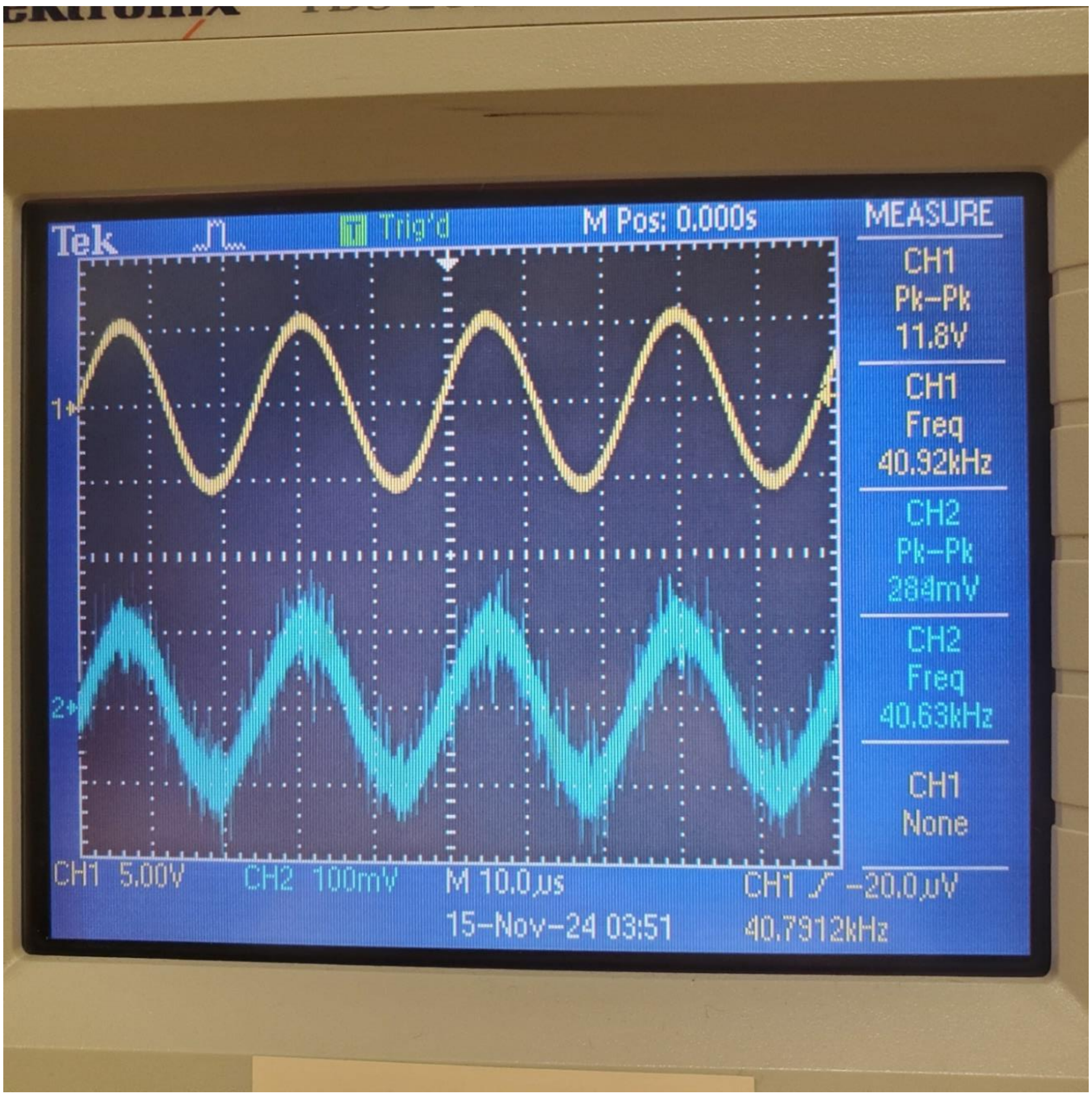
Part 2b - Construct the physical circuit of part 1d for L=1mH, C=100nF

With an oscilloscope and function generator, find the center frequency (in Hz): 15916 Hz

Find the low cutoff frequency (in Hz): 11253 Hz

Find the high cutoff frequency (in Hz): 22512 Hz

Place an oscilloscope picture of the input and output signals at the center frequency below:



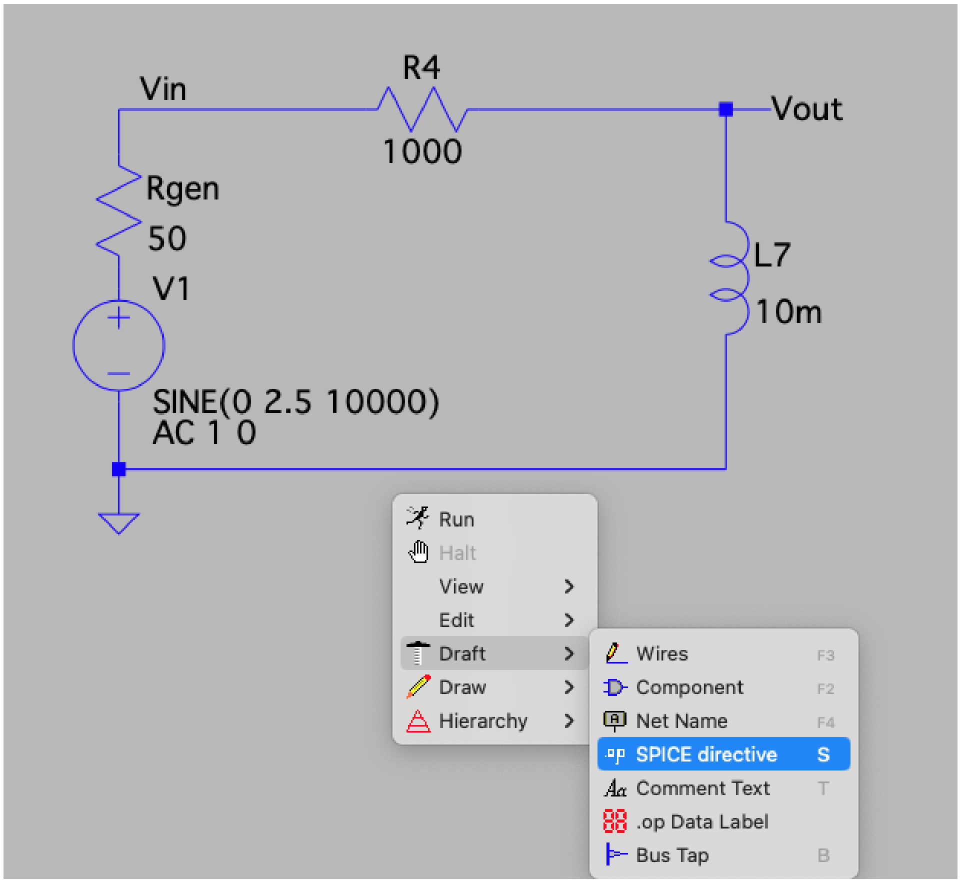
Conclusions (write a conclusion statement that discusses each of the purposes of the lab):

In this lab, we were introduced to performing AC frequency sweeps in SPICE and used this in our simulations of low-pass, high-pass, bandpass, and bandreject filters. Using the simulations we examined the cutoff frequencies, center frequencies, bandwidths, and quality factors of each. We then constructed the band filters and used the function generator and oscilloscope to find the center and cutoff frequencies.

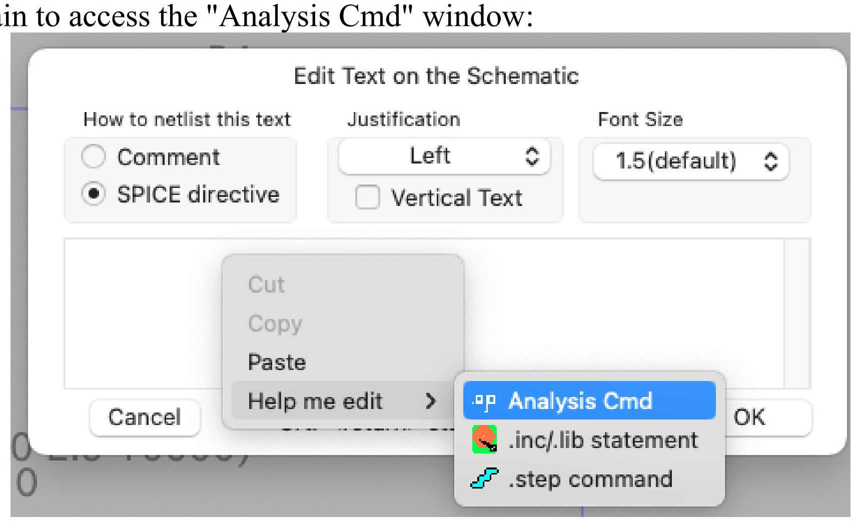
Lab8 Appendix

The SPICE directive ".ac dec 100 1 10meg" has more meaning if you add it in the following manner:

Right-click to access the "SPICE directive" window:



Right-click again to access the "Analysis Cmd" window:



Select the AC Analysis Directives :